Remarks

In response to the final Office Action mailed June 8, 2009, Applicants file the present Amendment and Reply within two months of the mailing date of the final Office Action. Claims 1-40 are pending. Claims 1-40 stand rejected for the reasons discussed below.

With the present Reply and Amendment, Claim 1 is amended to recite that the membrane that divides the first and second chambers membrane comprises a porous support and a catalyst. Claim 1 is further amended to recite that the membrane is adapted to activate molecules of the first reactant without forming an ionic species before reaction with the second reaction. Support for the amendments to claim 1 exists throughout the specification including, but not limited to, claim 5 (currently cancelled) as well as page 6, lines 27-29 and page 6, lines 11-18 of the specification as filed (WO 2004/98750). Claim 17 is amended to recite "a second reactant" thereby correcting the antecedent basis issue discussed below. No new matter is presented.

Claim Rejections – 35 USC §112

Claim 17 stands rejected under 35 U.S.C. §112 due to insufficient antecedent basis for the limitation "the second reactant." With the present Reply and Amendment, Applicants amend the phrase to read as "a second reactant." Withdrawal of the rejection is requested in view of this amendment.

Claim Rejections – 35 USC §103

Claims 1-40 stand rejected under 35 U.S.C. §103. Specifically, the Examiner sets forth the following rejections:

1. Claims 1-3, 5, 12-25, 28, 29, 30 and 40 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Barnes in view of Abeles;
2. Claims 22 and 24 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Barnes in view of Abeles;
3. Claims 4, 6, 7, 8, 9, 10, 11, 31 and 36 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Barnes in view of Abeles and further in view of Carolan;
4. Claims 26 and 27 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Barnes in view of Abeles and further in view of Roberts and Galloway;

5. Claims 32, 33, 34, 37, 38 and 39 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Barnes in view of Abeles and further in view of Oki and Moon.

With respect to independent claim 1, the Examiner contends that Barnes teaches one catalytically active metal supported on a catalyst support consisting of an aluminum-containing alloy and that the first reactant is imparted with enough energy so as to react with the second reactant. The Examiner admits that Barnes does not teach the use of chambers in the apparatus but believes that Abeles teaches a first chamber, a second chamber and a membrane dividing the first and second chambers to allow passage of the first reactant from the first chamber to the second chamber through the membrane. Thus, the Examiner concludes that it would have been obvious to one of ordinary skill in the art at the time of the invention for Barnes to have used the chambers of Abeles to facilitate the reaction of the two reactants.

With respect to independent claim 17, the Examiner contends that Barnes teaches the method of producing hydrogen gas in which a membrane consisting of a support and a catalyst by sending the first reactant through the support and catalyst allowing the first reactant to come into contact with the catalyst upon passage through the support and catalyst, imparting the first reactant with enough energy to react with the second reactant as well as reacting the first reactant with the second reactant to produce hydrogen gas.

Applicants respectfully traverse the rejections under §103 for the reasons set forth below.

The USPTO bears the initial burden of factually supporting a *prima facie* conclusion of obviousness. As restated in MPEP §2143.03, all claim limitations must be considered. Further, as noted in MPEP §2142.02, the claimed invention as a whole must be considered. The Supreme Court has noted that the factual inquires for establishing a background for determining obviousness include, in part, determining the scope and content of the prior art as well as the differences between the prior art and the claims at issue. Against this background the obviousness or nonobviousness of the subject matter is determined. In this case, the Examiner fails to establish *prima facie* obviousness based on the scope and content of the prior art as well as the differences between the claimed apparatus and method and that disclosed in the prior art.

Significant and fundamental differences exist between the presently claimed apparatus and method and that of the cited references, Barnes and Abeles. In the instant independent claims 1 and 17, the reactant molecules are activated without forming an ionic species. Barnes fails to teach or suggest such a feature. Abeles fail to cure this deficiency. Abeles relates to using a mixed ionic electronic conductor membrane comprising a densely sandwiched structure between two porous layers as recited in claim 1 of Abeles. The membrane in Abeles is specifically used for the partial oxidation of hydrocarbons which relates to the promotion and generation of <u>oxygen ions</u>. Abeles must use a mixed ionic electronic conductor membrane that generates oxygen ions for the preparation of the gaseous species. A combination of Barnes and Abeles cannot yield the apparatus of claim 1 nor carry out the method of claim 17. Thus, the instantly claimed apparatus and corresponding method are more than the predictable use of prior art elements according to their established functions.

Assuming, *arguendo,* that a person skilled in the art combined the teaching of Barnes and Abeles, the person skilled in the art would be lead to use a mixed ionic electronic conductor membrane which generates <u>ionic species</u> and would therefore still <u>not</u> arrive at the present invention. Generating ionic species does not occur within the instantly claimed apparatus (see amended claims 1 and 17 which each now specifically recite an ionic species is not formed before reaction with the second reactant). That is, claim 1 is amended to recite that the membrane is adapted to activate molecules of the first reactant <u>without</u> forming ionic species before reaction with the second reactant. Neither Barnes nor Abeles teaches or suggests this feature nor would one of ordinary skill have even considered such a feature due to the problems and challenges outlined below.

Further, a person skilled in the art looking at the highly inefficient and expensive system (discussed, *infra*) disclosed in Barnes in combination with Abeles with the objective of attempting to increase the formation of synthesis gas and allow the gaseous matter to flow more easily, would have been motivated to eliminate the porous top layer (layer 1). Removal of the porous top layer would result in a system which does not have a porous layer as a top layer and, instead, would have a dense mixed ionic conductor supported on a porous support (See Figure 3 of U.S. Patent No. 7,229,537 below where "10" is a dense mixed conductor layer and "20" is a porous layer).

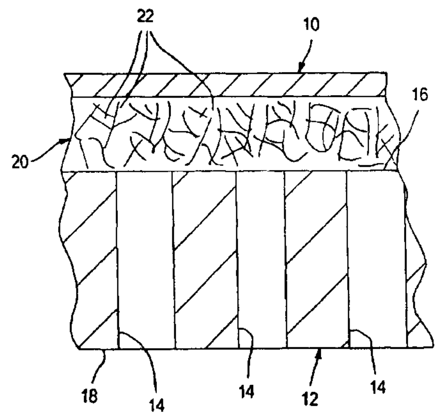


Figure 3 of U.S. Patent No. 7,229,537

Furthermore, the system described by Abeles would have to satisfy many physical requirements which include: (a) high oxygen permeation rates; (b) long-term chemical; (c) thermal stability under working conditions; and (d) good mechanical properties. Therefore, a person skilled in the art looking at Barnes in view of Abeles in an attempt to improve both mechanical properties and oxygen permeation rate, would be led to separate the two functions by using a porous substrate coated by a thin mixed ionic membrane layer (i.e., dense layer) (See Figure 3; U.S. Patent 7,229,537). The porous layer ensures proper mechanical properties and ensures oxygen diffusion. The dense mixed ionic membrane is no longer inhibited by a porous layer. Such an approach is in complete contrast to the present invention. Thus neither Barnes nor Abeles alone or in combination teach or suggest the instantly claimed apparatus or method.

Secondly, the gases such as oxygen and methane can be fed separately into the apparatus of claim 1 thereby preventing any risk of explosion occurring. Explosions are possible during use of the apparatus of Barnes due to the reactant gas mixture (see column 4, lines 48-67). In turn, the method described in Barnes is highly susceptible to gas explosions. In support of this position, Applicants feature Figures 1(a)-1(c) and Figure 2, below, which further exemplify and compare the presently claimed apparatus with that of Barnes and Abeles. Figure 1(a) relates to the invention disclosed in Abeles and shows that air being fed into the catalyst area comprises around 79% oxygen and 21% nitrogen. This airflow then interacts with the mixed ionic electronic conductor membrane which is non-porous to the nitrogen but allows the oxygen to permeate through and be converted to oxygen ions. Figure 1(b) also illustrates Abele's oxygen

activation catalyst and shows that most of the pores do not actually extend fully through the porous oxygen activation layer but only a very small percentage (interconnected pores) extends through to the mixed ionic electronic conductor membrane (See Figure 1(c).

Figure 1(a)

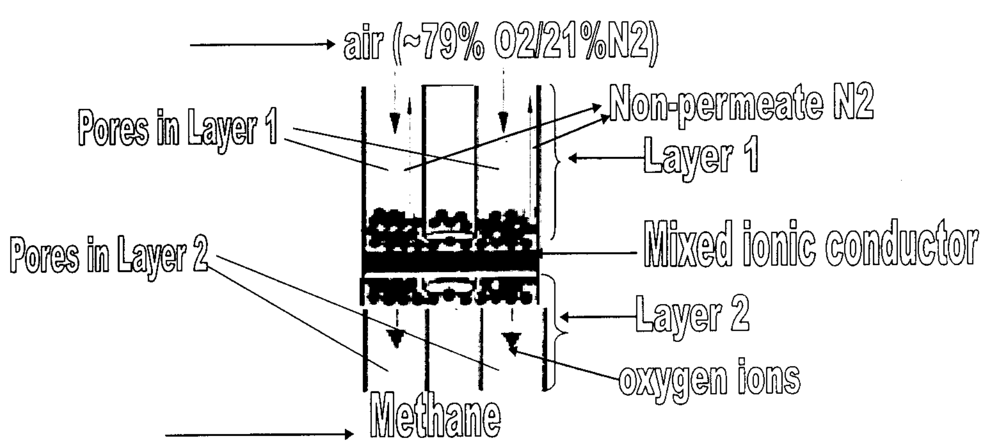


Figure 1(b)

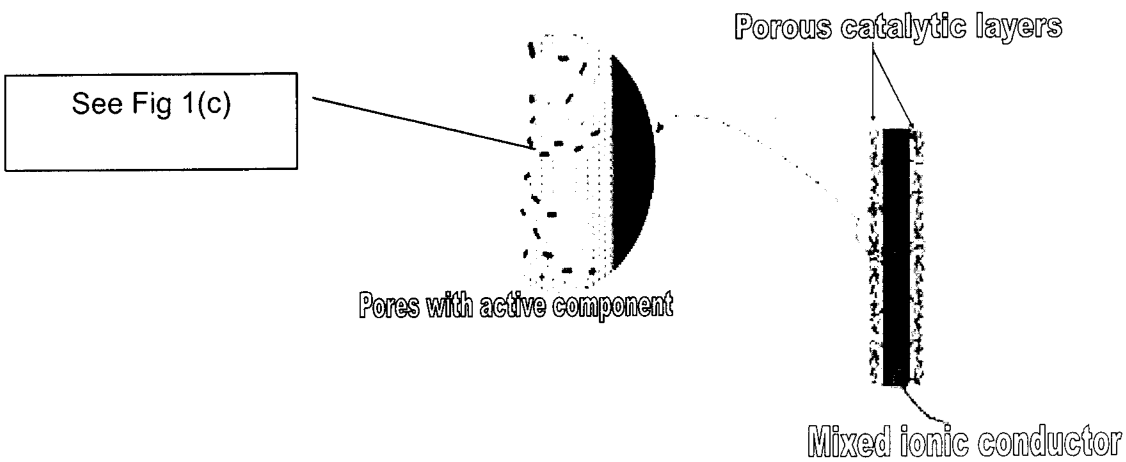


Figure 1(c)

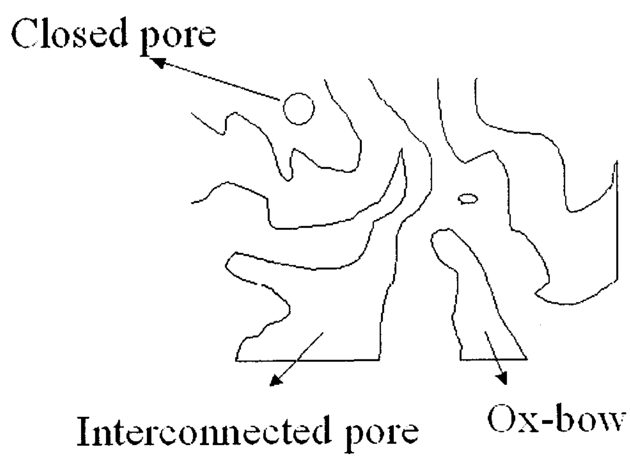
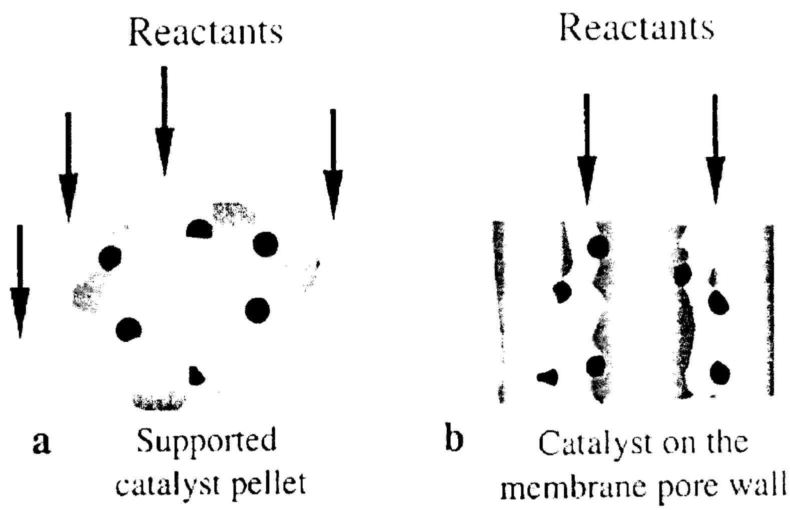


Figure 2 illustrates the Barnes invention wherein methane and oxygen are mixed and are then passed through a supported catalyst pellet arrangement in a fixed-bed to form synthetic gas. Thus, Barnes does not teach the use of chambers.

Figure 2



To further delineate the differences between the claimed apparatus and method and that of the cited prior art, Applicants note the following problems and challenges that are overcome by the instant apparatus and method:

1. <u>Efficiency</u>

The efficiency of the device in Abeles is severely limited by the fact that the pores do not fully extend through the oxygen activation catalyst. As a result, the porous substrate tends to slow down the air flow that reaches the dense mixed ionic membrane. Since nitrogen does not penetrate the mixed ionic transport membrane, it is forced to flow upwards in an opposed fashion to the oxygen, thus further reducing flux of oxygen through the pores. This is also a major limitation with Barnes as all the pores are dead-ended.

2. Thickness of the mixed ionic conductor

To enhance the oxygen flux density, the minor conductivity should be enhanced. Furthermore, membrane thickness should be reduced to increase the oxygen flux density unless the surface exchange reaction limits the oxygen evolution rate.

3. Material

Another challenge is locating an appropriate material for the porous layer. This material must satisfy some requirements such as chemical compatibility with dense membrane, sintering conditions with similar shrinkage behavior, and similar thermal expansion. A first solution consists in using the same material for the dense and the porous membranes, however, raw materials of the mixed ionic membrane are very expensive and, as a result, the cost of the catalytic membrane reactor would have to be decreased for an industrial use.

4. Chemical stability

Another important issue is chemical stability. When the oxygen permeable ceramics is utilized for the natural gas reforming, the material is exposed to a reducing atmosphere at the synthesis gas side and an oxidizing atmosphere at the opposite side, simultaneously. A large oxygen partial pressure gradient of about $0.21\text{x}10^{-20}$ atm exists between surfaces. Therefore, the chemical stability of the system under such severe conditions is required in addition to the high oxygen flux density. Novel materials with high oxygen permeation properties and chemical stability are therefore required, but such materials are very expensive.

Since the independent claims are not obvious, the claims depending therefrom are likewise not obvious. Applicants refer to MPEP §2143.03. Thus, Applicants need not address the specific contentions concerning the dependent claims and the remaining cited references, Carolan, Roberts, Galloway, Oki, and Moon.

Applicants request withdrawal of each of the §103 rejections.

Conclusion

Applicants believe the proposed claims are in condition for allowance and such action respectfully is requested. If the Examiner has any matter outstanding for resolution, he is encouraged to telephone the undersigned for expeditious handling.

Respectfully submitted,

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